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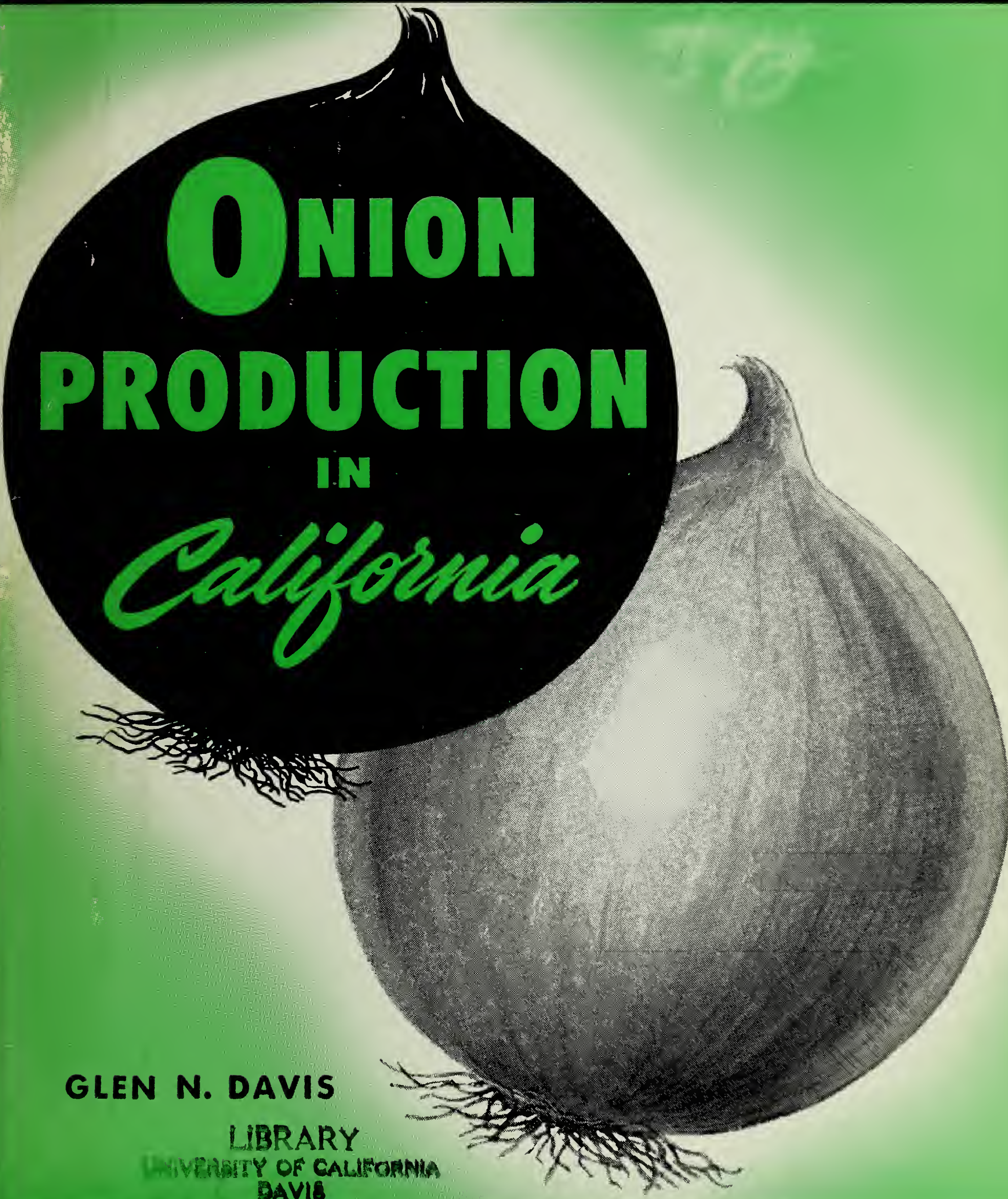
UNIVERSITY OF CALIFORNIA



ONION PRODUCTION IN California

GLEN N. DAVIS

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MANUAL 22
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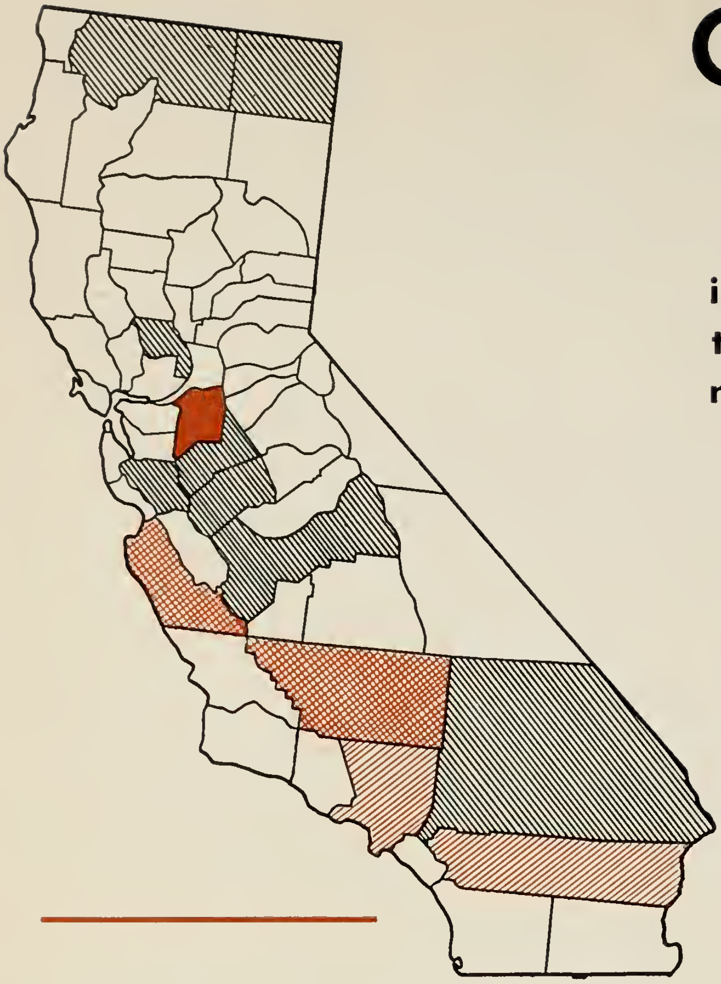
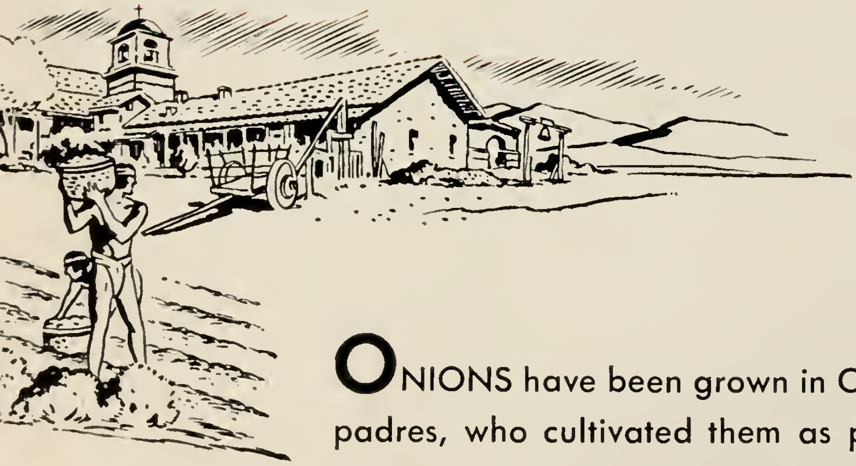
ONION PROD

Commercial production of onions is fairly well scattered throughout the entire state, as indicated by the map.





ONIONS have been grown in California since the days of the Spanish padres, who cultivated them as part of the food supply for the early missions. Commercial growers first became interested in the crop in 1874, and by the end of the nineteenth century the shipping of onions and growing of seed were well established.

Today California is a leading onion-producing state, with acreage in onions from one end of the state to the other. In 1952 it ranked second to New York, producing 15 per cent of the national commercial crop. In addition, California is one of the chief onion seed-producing areas of the world.

At first, production was largely confined to late onions, which still tend to dominate the annual crop, but about 1910 early-maturing

UCTION IN CALIFORNIA

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varieties began to be grown in the desert valleys, and in some years this acreage has equalled or surpassed that of the late crop. Shipping of early onions has increased, but the out-of-state movement of late onions has declined in recent years. Part of the crop is dehydrated. This outlet has been quite important since World War II, resulting in a marked increase in the late summer crop. In 1952, 49 per cent of the late crop was dehydrated.

Onions are one of California's major vegetable crops, although by comparison with some other vegetables grown in the state, the total acreage in onions is relatively small. In 1954 approximately 10,000 acres of farmland was planted to onions, with a crop market value of about $7,500,000.

In terms of cash returns to the grower, the onion ranks eighth in the state, being preceded by potatoes, tomatoes, lettuce, celery, carrots, cantaloupes, and asparagus. In the last ten years improved varieties and cultural practices have raised the average yield from about 450 to 600 fifty-pound bags per acre.

The information in this manual will be of interest to the experienced onion grower as well as the beginner.

NATURAL REQUIREMENTS

Temperature, soil, and moisture conditions are all important in onion-growing. Does your location meet the requirements described below?

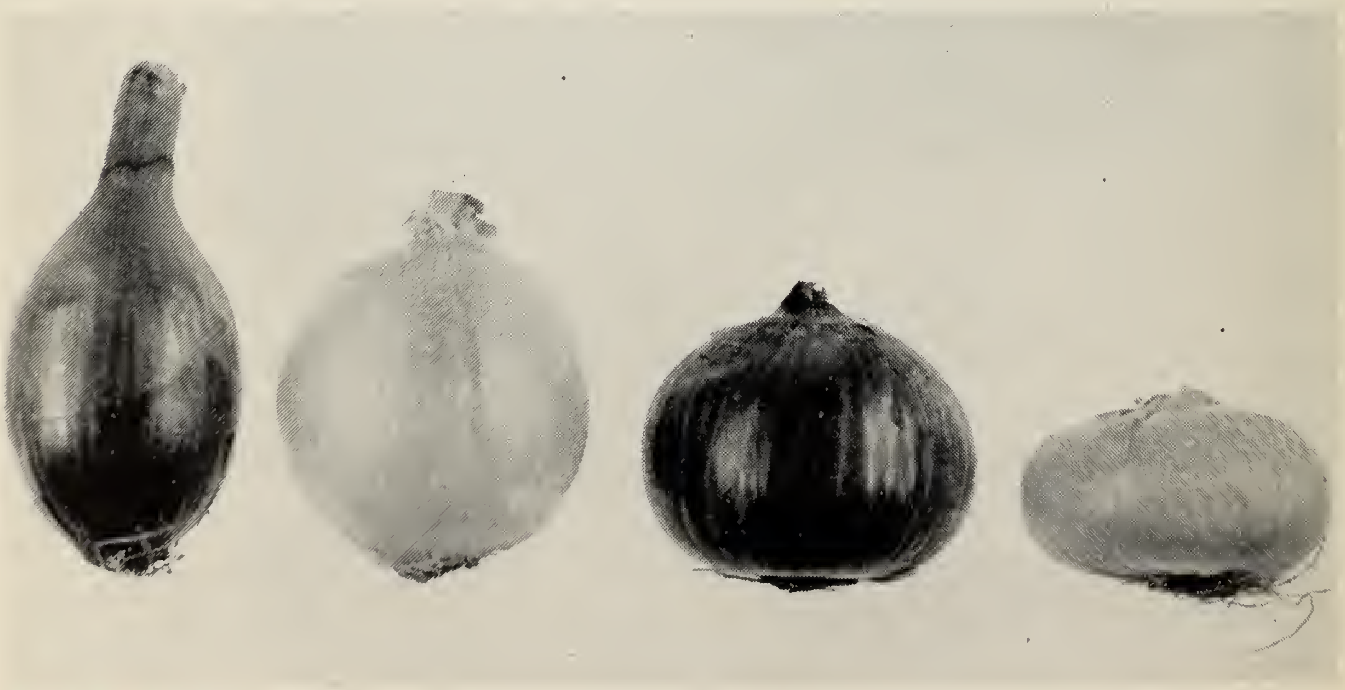
Climate

Early in the growing season onions thrive best in cool weather. The young plants are quite tolerant to cold and will withstand temperatures several degrees below freezing. Later, for proper maturity, they need a dry atmosphere and moderately high temperatures. In California the growing season is largely during late fall and winter, with the bulbs maturing from early spring into summer depending on the variety being grown.

Proper temperature and long exposure to light are necessary for onion-bulb formation. Onions planted in the fall and winter generally grow a luxuriant foliage, but bulbs are not formed until spring or summer when longer days and higher temperatures promote bulb formation. The early and intermediate varieties (spring crop) produce bulbs on exposure to moderate temperature and relatively short periods of daylight. In contrast, the varieties grown for the summer or storage crop require relatively high temperatures and exposure to long periods of daylight for bulb formation. The onions of this group generally do not mature before late August or September.

Soil

A suitable soil is of fundamental importance in onion growing. The most desirable type of soil is one that under cultivation will retain enough moisture about the roots and at the same time be friable (easily crumbled) enough to be easily cultivated and to allow proper expansion of the bulbs. It should be fertile, well supplied with humus, and as free as possible of weed seeds.



BULB TYPES From left to right—torpedo, globe, low globe or high flat, and flat.

The onion crop is grown mainly on sandy loams, silty loams, and peat. Heavy clay and coarse sand or gravel should be avoided.

Moisture

The onion is one of the most shallow-rooted of the vegetable plants. During early growth it needs abundant soil moisture near the soil surface. The plants will suffer less from too much moisture than from too little. New roots are not formed unless the soil zone they are in is moist. The plants must be kept growing. If growth is checked temporarily by shortage of water, the outer scales seem to mature; when water is again supplied, the inner scales resume growth, causing the outer ones to split. This is one of the main causes of "splits" and "doubles" where onions are grown under irrigated conditions. For maximum yields the moisture must be maintained in the surface 6 to 10 inches of soil.

THE VARIETIES

Standard, open-pollinated varieties are still commonly grown in California, but new hybrids are coming into use.

Onion varieties are in a state of flux at present and are likely to remain so for the next few years. A number of new hybrid combinations have been tested and named, and seeds are now available in quantity to commercial growers. Many more hybrids are being tested and developed. In time, hybrids will undoubtedly replace many of the standard varieties now being grown. These, in turn, may be replaced by further improved hybrids. At present, however, few of the new hybrids have become established, and none have completely replaced the open-pollinated varieties that have been grown for many years. The result is a constantly changing picture, and it is rather doubtful that any present discussion will long remain valid.

To provide the information available to date without attempting to suggest future development, lists of standard varieties (table 3) and hybrid varieties (table 4) are included. The standard varieties are those that are adapted to and have been grown under California environmental conditions. The list of hybrid varieties in table 4 is as complete as it is possible to make it at the present time. This list is provided for information only—it does not imply adaptability to California growing conditions.

Before you plant hybrid varieties, therefore, consult your local Farm Advisor or some other reliable source of information regarding the adaptability of hybrids to your local climatic conditions.

THE TABLES on pages 6 and 7 list both standard and hybrid onion varieties and give some of the characteristics of each.

Hybrid Onion Varieties and Some of Their Characteristics

(Hybrids available to date; adaptability to California conditions not determined)

Name	Adaptation	Maturity	Bulb characteristics			Flavor	Storage period
			Size	Shape	Color		
Abundance	Long day	Midseason to late	Large	High globe	Light yellow	Pungent	Medium
Aristocrat	Long day	Late	Medium to large	Globe to high globe	Yellow	Pungent	Long
Asgrow B46	Long day	Midseason to late	Medium to small	Full globe to slightly flat	Dark reddish brown	Very pungent	Very long
Asgrow B47	Long day	Midseason to late	Medium	Semi-globe	Dark reddish brown	Very pungent	Very long
Asgrow W1	Short Day	Second early	Medium to large	High flat	White	Mild	Short
Asgrow W45	Long day	Midseason	Medium	Full globe	White	Medium pungent	Medium
Asgrow Y2	Short day	Early	Medium	High flat	Yellow	Mild	Short
Asgrow Y40	Intermediate	Second	Medium	Full globe	Yellow	Mild	Short
Asgrow Y41	Long day	Second	Medium	Globe	Yellow	Mild	Medium
Asgrow Y42	Long day	Second	Medium	Globe	Yellow	Mild	Medium
Asgrow Y43	Long day	Late	Medium to large	Full globe	Yellow	Medium pungent	Medium
Asgrow Y44	Long day	Second early	Medium	Flattened globe	Yellow	Medium pungent	Medium
Asgrow Y49	Intermediate	Midseason	Medium	Globe	Yellow	Mild	Short
Asgrow Y50	Intermediate	Midseason	Large	Flattened globe	Yellow	Medium pungent	Medium
Asgrow Y52	Intermediate	Midseason	Large	Globe	Light yellow	Mildly pungent	Medium
Asgrow Y53	Intermediate	Midseason	Large	Globe	Yellow	Medium pungent	Medium
Autumn Brown	Long day	Midseason	Medium	Globe	Dark brown	Medium pungent	Long
Autumn Chief	Long day	Late	Large	Deep globe	Straw	Pungent	Long
Autumn Glory	Long day	Midseason	Medium	Nearly round	Brown	Pungent	Long
Autumn Spice	Long day	Late midseason	Medium	Round	Brown	Very pungent	Long
Autumn Star	Long day	Late midseason	Large	Deep ovate	Straw to brown	Pungent	Medium
Bonanza	Long day	Late	Medium to large	Globe to high globe	Yellow	Pungent	Long
Brown Beauty	Long day	Late midseason	Large	Globe	Brown	Mild	Long
Burpee Crystal Wax Hybrid	Short day	Early	Medium	High flat	White	Mild	Short
Burpee Yellow Globe Hybrid	Long day	Midseason	Medium to large	Flattened globe	Yellowish brown	Mild	Long
California Hybrid Red No. 1	Short day	Midseason	Large	Globe	Purplish red	Mild	Short
Castilian	Short day	Early	Medium to large	Oblate	Medium brown	Mildly pungent	Medium
Champion	Long day	Late	Large	Globe to high globe	Dark yellow	Pungent	Medium
Contender	Long day	Late	Large	Globe to high globe	Light	Pungent	Medium
Crystal Hybrid	Short day	Early	Medium	Flat	White	Mild	Short
Early Harvest	Intermediate	Early	Medium	Globe	Light yellow	Mildly pungent	Short
Elite	Long day	Late	Large	Globe to high globe	Yellow	Pungent	Long
Encore	Long day	Late	Large	Globe to high globe	Yellow (dark)	Pungent	Medium
Epoch	Long day	Late	Medium	Globe to high globe	Dark yellow	Pungent	Long

Fiesta	Long day	Late	Large	Globe to high globe	Copper yellow	Pungent	Long
Granex	Short day	Early	Large	High flat	Yellow	Very mild	Short
Magnifico	Long day	Late	Very large	Globe	Yellowish brown	Mild	Short
Pioneer	Long day	Late	Medium	Globe	Dark yellow	Pungent	Long
Premier	Long day	Late	Large	High globe	Dark yellow	Pungent	Long
Snow White	Long day	Late	Large	Globe	White	Pungent	Long
Spotlight	Long day	Late	Medium	Flattened globe	Yellow	Pungent	Long
Surprise	Long day	Late	Medium to large	Globe to high globe	Dark yellow	Pungent	Long
Texas Hybrid 28	Short day	Early	Medium	Flat	Yellow	Mild	Short
Vaughn's Hybrid Sweet Spanish No. 1	Intermediate	Midseason	Large	High globe	Yellow	Mild	Short
White Granex	Short day	Early	Medium	High flat	White	Mild	Short

Varieties of Onions Adapted to California and Some of Their Characteristics

Variety	Adaptation	Maturity	Bulb characteristics			Flavor	Storage period
			Size	Shape	Color		
Crystal Wax	Short day	Early	Medium	Flat	White	Mild	Short
Excel	Short day	Early	Medium	Flat	Yellow	Mild	Short
L36	Short day	Early	Medium	Flat	Yellow	Mild	Short
L365	Short day	Early	Medium	Flat	White	Mild	Short
San Joaquin	Short day	Early	Large	Globe	Yellow	Mild	Short
Cal-red	Intermediate	Midseason	Large	Deep flat	Purplish red	Mild	Short
Early Grano	Intermediate	Midseason	Large	Top-shaped	Yellow	Mild	Short
Italian Red	Intermediate	Midseason	Large	Torpedo-shaped	Red	Mild	Short
Stockton Yellow Globe	Intermediate	Midseason	Large	Semiglobe	Straw	Mild	Short
Australian Brown No. 5	Long day	Late	Medium to small	Flattened globe	Brown	Pungent	Long
Southport White Globe	Long day	Late	Medium to large	Globe	White	Pungent	Medium
White Sweet Spanish	Long day	Late	Large	Globe	White	Pungent	Medium
Yellow Sweet Spanish	Long day	Late	Large	Globe	Yellow	Pungent	Medium
Yellow Globe Danvers	Long day	Late	Medium	Globe	Yellow	Pungent	Long

CULTURAL METHODS

During the growing season onions need special care. Cultural practices recommended for California conditions are described below.

Preparing the land

No vegetable crop is more dependent on a properly prepared seedbed than the onion. Assuming that the soil can be brought to a good mechanical condition, the first step is to plow moderately deep, then disk, harrow, and drag until the soil is free from clods and is smooth and mellow to a depth of 5 to 7 inches. The amount of preparation needed will depend upon the character of the soil, the planting method to be followed, and the irrigation requirements. If manure or covercrops are to be turned under, plowing should come early enough for the material to rot thoroughly before planting time. For onions, manure does not have to be turned under as deeply as for most other vegetables.

If the soil is well drained and if there is no danger of surface water accumulating, bedding the soil is not essential; the crop may be drilled or transplanted into rows on the flat. This system is generally followed on peat soils. On most mineral soils, where drainage is not sufficient and surface water may accumulate, it is a common practice to construct beds after the soil has been plowed and harrowed. As a rule, the beds are 26 to 36 inches from center to center and 8 to 12 inches high. Their tops are smoothed, or "broken down," with a sled or drag before the seeding or transplanting.

PLANTING Below—beds prepared for drilling seed or transplanting onions. Photo at right shows a rig used on peat land, which drills fertilizer and seed in 10 rows at a

Planting

Two methods of planting are used in commercial onion growing in California. Seeds may be planted in a seedbed or nursery and later transplanted into the field, or they may be drilled into the soil in rows where the crop will be grown.

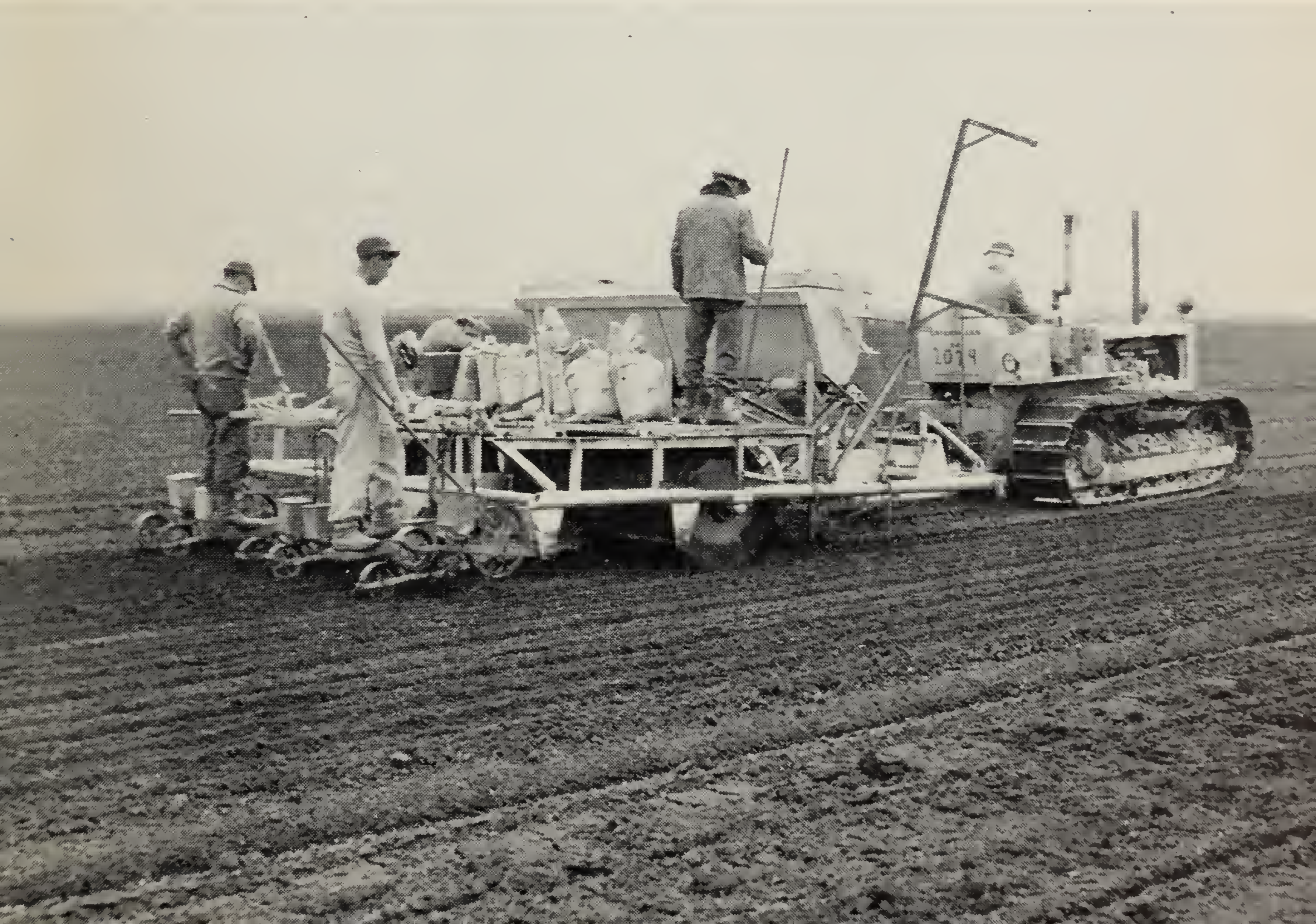
Transplants. Onions belonging to the early and intermediate groups are often grown from transplants. Seeds are planted thickly in rows that are 2 to 10 inches apart, or they may be broadcast in seedbeds and covered lightly with soil. In either case planting should be done 6 to 10 weeks before the plants are to be transplanted.

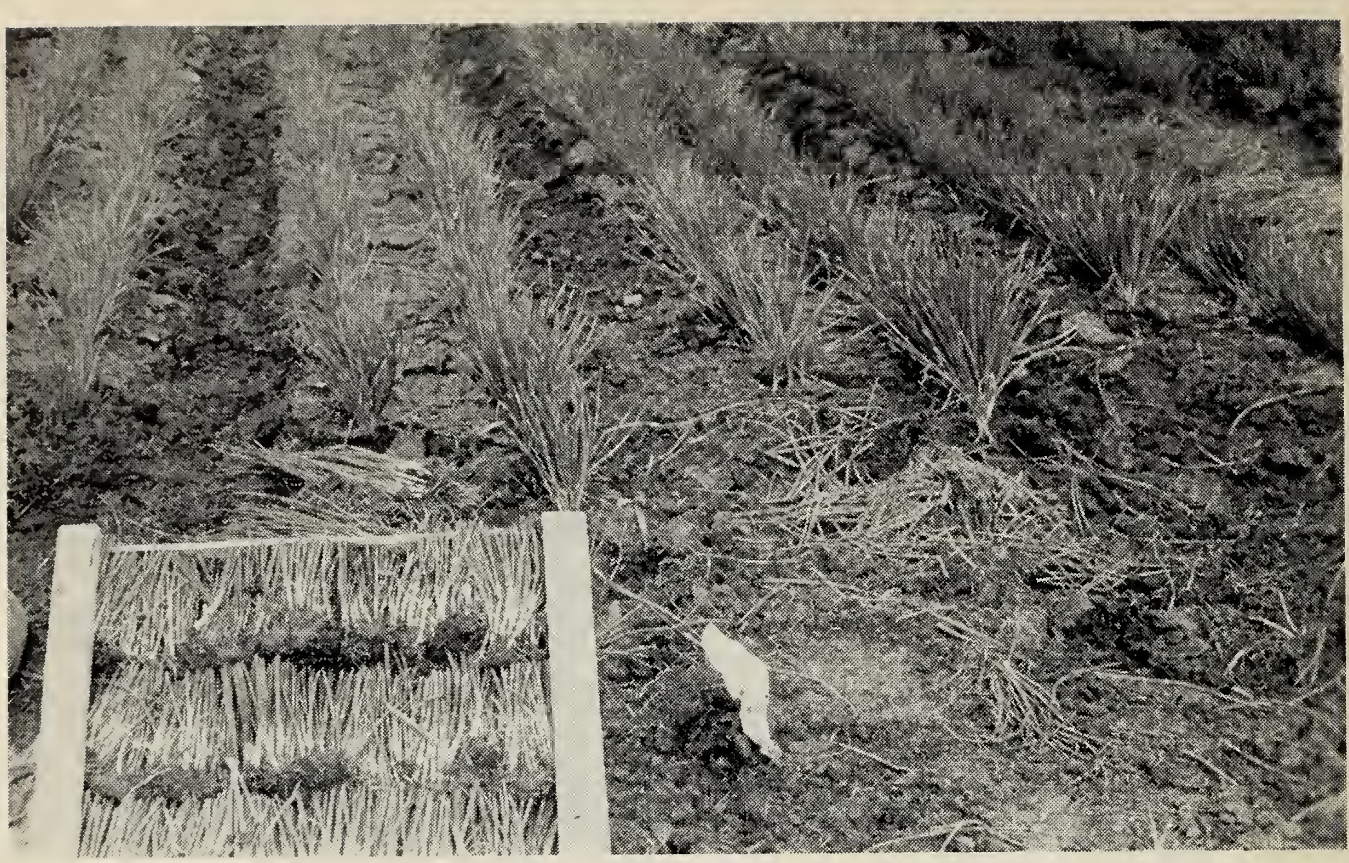
In California, open beds are more commonly used than hotbeds. The date of planting depends on the area of the state, the variety to be planted, and the time when you want the crop to mature. The planting date is usually sometime in September. With seed of good quality, ½ to 2 pounds should produce enough plants to transplant one acre.

Transplanting should be done as early as feasible to insure abundant top growth before the start of bulb formation. The plants should be removed to the field when they are ¼ to ⅜ inch in diameter—that is, between the last of November and the first of March, the exact time depending largely on the date the seed was planted and on local environmental conditions. Larger plants show a tendency to produce seedstalks.

Irrigate the plants a few hours before digging them. You can dig them with a shovel or loosen them by running a cultivator knife or blade below them in such a way that 2 or 3 inches of roots will remain attached to the plants. After they have been dug, the plants should be separated from each other. The tops may be trimmed to the top of the central leaf blade, and the roots trimmed until they are ½ to 1 inch long. Trimming does not benefit the plant, but it is recommended for easier handling during transplanting operations. From the time the

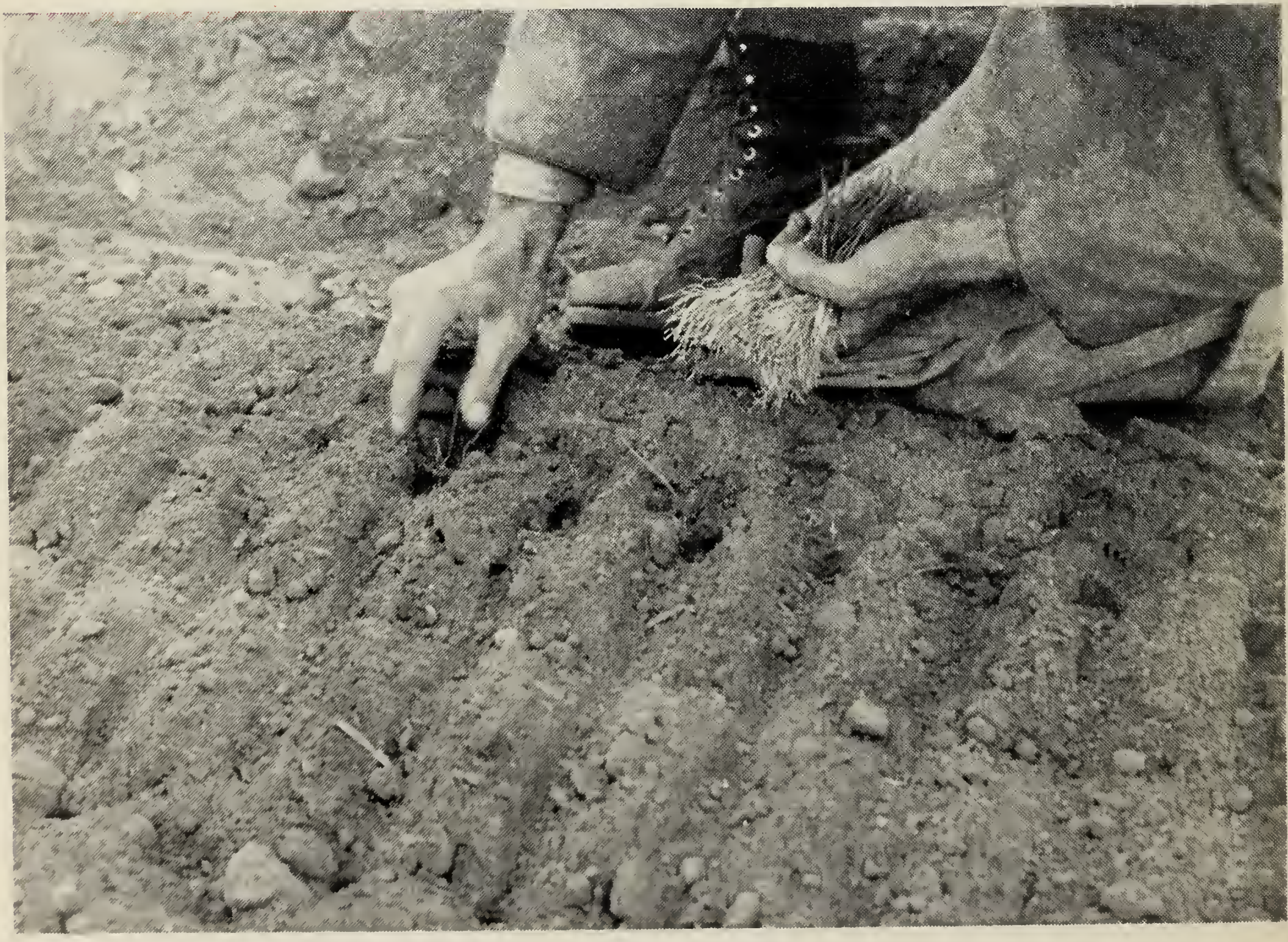
time directly into a previously prepared seedbed. Compaction wheels firm the soil in place over the drilled seed. (Photograph taken on Zuckerman farm near Stockton, California.)





TRANSPLANTING

Photo above shows onion seedlings trimmed and prepared for transplanting. Note size of plants in the box. Photo below shows transplanting of seedlings into indentations made by a roller marker. (Lower photo courtesy David N. Wright.)



seedlings are removed from the beds until they are transplanted, they should be covered to keep the small roots from drying.

Methods of transplanting. The seedlings can be transplanted by placing them in a previously opened furrow. The roots and base of the plant are covered by pulling the soil back into the furrow with a rake or a power-drawn lister-type cultivator shovel.

They may be planted with a dibble, in which case no furrow is needed; a small hole is opened for each individual plant. The exact location for each plant is often marked on the bed tops by using a roller with knobs or extensions about 3 inches apart. The soil should be firmed around the root by a second stroke in which the dibble is inserted into the soil at an angle at the side of each plant. In most districts two rows are transplanted to the top of each plant bed.

Sometimes low beds, 12 to 18 inches from center to center, are used, and a single row of transplants is arranged on top of each bed. This is true of areas such as the Coachella Valley, where the soil is extremely light or sandy and the water subirrigates laterally only a short distance from the irrigation furrows.

Direct seeding. Most of the onion crop grown for late market or storage, as well as a considerable part of the early-maturing crop, is seeded directly into the field. The direct-seeded early crop is planted from mid-October to late November depending on the location and the variety. The late crop should be seeded as soon after January 1 as weather conditions will permit.

For direct seeding, the soil should be finely pulverized and free from debris. Seed is usually sown at the rate of 3½ to 4 pounds per acre and at a depth of ½ to 1 inch, according to the soil type. The deeper plantings are made on the lighter soils.

Various types of seeders are used, run singly or in gangs. For planting on previously prepared beds, two rows are drilled on the top of each bed. For planting on the flat, rows are spaced 8 to 18 inches apart, the distance depending on the method of cultivation to be used.

Cultivation

Onions are cultivated with hand implements or power-propelled cultivators; the size of the field and the spacing determine the type of machine to be used.

Because the plant is shallow-rooted, too deep cultivation must be avoided, for it may destroy many of the roots near the surface of the soil.

Some hand-weeding is almost always essential. In favorable seasons two or three weedings may be enough; in wet seasons more will be needed. Certain small tools are helpful—for example, the onion hoe, the hand-weeder, and the thinning or weeding hook.

Fertilizers

The onion is an intensive crop and should yield large quantities of marketable bulbs for the area planted. Since the plant is shallow-rooted, a fairly high concentration of plant nutrients must be maintained in the upper foot of soil. A comparatively heavy application of fertilizer is therefore justified.

Many fertilizer experiments with onions have been conducted in all of the important producing areas of California with the following results:

On **light-textured soils,** such as sands or fine sandy loams, the land should be fertilized with 120 pounds per acre each of nitrogen (N) and phosphoric acid (P_2O_5). Ammoniacal or other nonleaching forms of nitrogen should be used unless you wish to make several applications. Ammonium sulfate has proved to be an excellent source of nitrogen for onions. Aqua ammonia and anhydrous ammonia may burn the plants if placed close to young seedlings.

On the **heavier mineral soils** 60 pounds per acre each of nitrogen and phosphoric acid is generally enough. Onions grown on mineral soils do not usually respond to potash.

Peat soils of the Delta region vary greatly in their need for fertilizer, depending largely upon previous fertilizer application. On peats that have not been fertilized heavily in previous years as much as 120 pounds each of nitrogen, phosphoric acid, and potash may be needed. These nutrients could be supplied by using 1,200 pounds per acre of a 10-10-10 fertilizer. On peats that have been intensively fertilized for previous crops, the phosphoric acid and potash application can be reduced or in some cases even eliminated. The peat soils at Tulelake give only slight responses to fertilizers, and 60 pounds per acre each of nitrogen and phosphoric acid is usually enough.

When to apply. Onions require a good part of the fertilizer early in the growing season. The plants develop a vigorous rooting system even in cold soils and before there is much top growth. All of the phosphoric acid and at least one third of the nitrogen should be applied when the crop is planted or transplanted; the remainder of the nitrogen should be applied before the crop is half-grown.

On soils that do not leach readily, all of the nitrogen can be applied at planting or transplanting. Split applications of nitrogen are recommended only for the very light soils that are readily leached. All of the water-soluble forms of phosphoric acid are acceptable, and equal yields have resulted from the application of single superphosphate, treble superphosphate, liquid phosphoric acid, and ammonium phosphate. The dicalcium phosphates are not recommended for use on alkaline soils.

How to apply. For best results, fertilizers should be placed close to the young seedlings. Transplanted onions usually produce the best from fertilizers placed 4 or 5 inches deep directly under the plant row. Direct-seeded onions are likely to be burned from heavy nitrogen applications too close to the plant, and placement 3 inches to the side and 4 inches below the seed is recommended.

Irrigation

Most of the onions produced in California need irrigation. The exact time of application and the amount are governed by the character of the soil and the season of the year. In the absence of rainfall the soil should be thoroughly irrigated before planting. Once the plants have started to grow, they must never suffer from lack of water. The number of irrigations necessary to maintain enough moisture near the soil surface is largely determined by the rainfall and the season.

When the plants start to mature, irrigation should be discontinued and the soil allowed to dry out as much as possible; otherwise a second root growth may start—one that is difficult to stop and that complicates the process of curing the onions properly. Under average conditions, the application of approximately 15 inches of water to the early and 24 inches to the late crop is suggested. Water should be applied with care as onions approach maturity. An oversupply during this period may tend to make the onions watery and reduce their keeping quality.

Weed control

Weed control often constitutes a major cost, particularly if it demands an excess of costly hand labor. This expense can be materially reduced by pre-emergence treatment with oil or by the use of selective herbicide sprays. Selective herbicides are chemicals that, when properly applied, will kill weeds without injuring crop plants, but their application must be carefully timed. To do the job they were designed for, they must be used on very small weeds; otherwise the amount of herbicide needed

IRRIGATION Growers in the San Joaquin Delta region use spud ditches similar to the one shown here for irrigation.

may also damage or destroy the crop. Butane burners rigged on tractors have also been used to remove weeds from the rows before the onion seedlings emerge from the soil. Proper timing of the burning is most critical, however, and this method of weed control has never been widely used.

Pre-emergence treatment. For the direct-seeded crop a pre-emergence oil spray has proved quite effective. The spray should be applied after the seeds are planted and before the small onion plants start to emerge from the soil. Stove oil or diesel oil applied at a rate of 20 to 40 gallons per acre is recommended. Application can be made with either a ground spray rig or by airplane.

Selective herbicides. The selective herbicide most commonly used on onions in California has been a Dinitro selective; several commercial formulations are available. Seeded onions should not be sprayed before they have two true leaves, and transplants should be well established and have renewed growth before being sprayed. Rates of 1 to 1½ gallons of the Dinitro selective in 60 to 100 gallons of water are used. The onions may be injured if the plants are sprayed when wet with dew or rain, or if the temperature is high. Rain immediately following application may reduce the spray's effectiveness and may cause injury to onions on peat or sandy soils. Large onions may be damaged if sprayed after the leaves have bent over. The Dinitro selective is more effective on broad-leaved weeds than on grasses.

Potassium cyanate is also used as a selective herbicide in much the same way. In general, the cyanate can be used on somewhat younger onions than the Dinitro, although weed control may not be quite as satisfactory in cold weather. Recommended rates are 1 pound to 12 gallons of water when the onions are less than 6 inches tall, and 1 pound to 6 gallons of water when the onions are more than 6 inches tall. Again, broad-leaved weeds are more readily controlled than grasses, and small weeds are most susceptible.

Transplanted onions may be kept free from weeds by applying Chloro IPC at the rate of 4 pounds per acre, one to three weeks after transplanting. Treatment is made with a ground spray rig, using 60 to 100 gallons of water per acre. Both grasses and the common winter-growing broad-leaved weeds are controlled with Chloro IPC. This chemical should not be used on direct-seeded onions and should be used with caution on light sandy soils, where selectivity may be less than on heavier soils.

To control weeds in an onion-seed crop Chloro IPC (as used with transplants; see above) is recommended. The spray should be applied soon after the mother bulbs are planted, since it is most effective on very small weeds. If the seed crop is produced by the seed-to-seed method, weed control is much the same as for the production of a commercial bulb crop.

CMU applied at the rate of 2 pounds (plus 60 gallons of water) per acre has been used with some success on seed crops grown on heavy soils. On light or sandy soils CMU is more liable to cause damage, depending on the amount of rainfall following application. CMU is very persistent in the soil and should first be used on a small scale to test its effectiveness on the soil concerned.

Consult your University of California Farm Advisor or some other reliable authority on local rates and practices in using chemicals for weed control in onions.

THE CROP

Handling the crop—when and how to harvest, cure, grade, and store.

Harvesting and curing

When the onion plants ripen properly, the leaves weaken in the region just above the bulb, and the top falls over while the leaves are still green. If the tops dry from the tips toward the base while the plants remain erect, the neck is not closed, and the bulbs may not keep well in storage.

Onions do not mature uniformly. The best time for harvest is when 15 to 25 per cent of the tops have broken over. Onions that are fully mature when pulled tend to root rather easily; this type of growth is difficult to check and unfits them for anything but immediate use. Onions pulled when they are slightly immature seem to retain their outer skins better and are less likely to sprout and root when curing. They are, however, often less solid than when pulled fully mature. The stage at which they are harvested should be determined somewhat by whether they will be stored or placed immediately on the market.

Rotting usually results from infection during growth or curing of the bulbs, but infection may also follow unfavorable storage conditions. Infection and subsequent rotting may be largely prevented by rapid and complete drying of the neck and outer bulb scales. In the case of soil organisms that enter through the roots and root plate, pulling the plants before the foliage has turned yellow may reduce rotting.

Onions are usually loosened in the soil by running some type of blade or cutter below the bulbs. They are then pulled by hand and thrown in windrows to dry before topping, or they may be placed in slat crates for curing. (While the practice is not a common one, onions are sometimes pulled and topped in one operation.)

In the warm interior valley, the bulbs usually dry in 4 to 7 days; in regions of cooler climate and higher humidity, it takes longer. Where the sun is hot, if the onions are piled in windrows the tops should be laid so as to protect the bulbs from sunburn—particularly with the white varieties.

When the bulbs are properly dry, the tops are removed by hand, either by twisting or cutting with a knife, shears, or power-driven mechanical toppers of which several types are available.

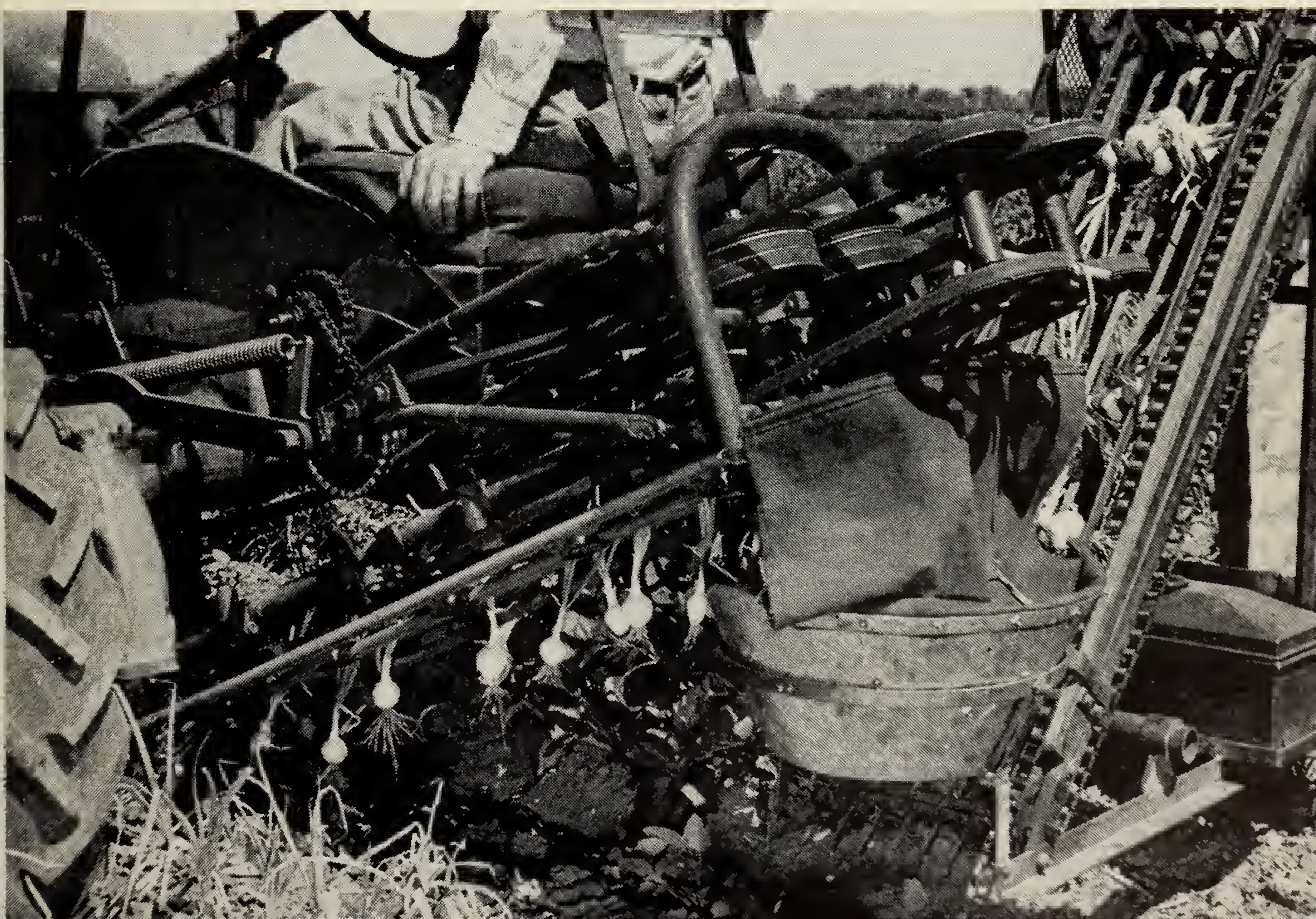
Immediately after topping, the bulbs are placed in sacks or slat crates and allowed to cure for a few days before they are taken to market or placed in storage. Onions of the early and intermediate crops are usually marketed immediately, whereas the late varieties are often stored.

Storage

Not all onion varieties are suitable for storing. Although it might be difficult to rank onions in the exact order of their keeping quality by the simple water-loss method of testing, onions that have a high relative rate of water loss or a high total water loss are definitely nonkeeping types. On the other hand, those with a low relative rate of water loss or a low total water loss will keep. Experimental data indicate that a simple test should normally suffice to classify an onion of unknown keeping quality. This is to measure the weight loss in two successive days after harvest of a lot of onions weighed in mass. There is no need to make actual time tests of keeping.

In California much of the onion crop is marketed directly after harvest. Bulbs of the varieties comprising the early and intermediate crops do not keep well in storage even under the most favorable conditions, and would be extremely difficult to store during the hot summer

HARVESTING This harvester, developed at Davis, lifts, tops, and bags onions in one operation. (Courtesy Coby Lorenzen.)



months. Late or storage types mature during late September or October, when they may be stored successfully until the following March, or even later if proper precautions are taken.

Onions intended for storage should be well matured and thoroughly dried or cured. Immature or soft onions should be sorted out, and only attractive, sound bulbs should be stored.

Slat crates, each holding about one bushel, are considered the most satisfactory containers for storage, although onions may also be stored in 50- or 100-pound sacks, or in bulk in bins. The bulk method is seldom satisfactory and should not be used if any alternative is possible. If you use sacks, pile them in pairs and lay them crosswise in stacks five or six sacks high. Set the stacks a few inches off the floor on wooden strips, and allow a few inches of space between stacks so that air can circulate.

Two general types of houses are used, the so-called "common storage" and cold storage. Common storage houses are generally waterproof sheds or barns. On warm winter days the buildings should be kept closed, and the doors are generally opened at night provided the weather is not too severe. Even though storage facilities are adequate, some rot or growth will often occur, and it is sometimes necessary to sort over the onions one or more times. All onions that have started to rot should be thrown out. Under moist conditions, a few rotten onions will spoil much of the container's contents. Bulbs usually store poorly after severe mildew or thrips attacks.

Cold storage by artificial refrigeration, where available, is the most satisfactory method of keeping onions over long periods. A temperature of 32° F and a relative humidity of 70 to 75 per cent or lower have been found to constitute optimum conditions. While high humidity will not cause tops to sprout, it does stimulate root formation regardless of the temperature.

Sprouting in storage can be delayed by spraying the onion plants just as the tops start to fall over with MH-40, a sodium salt of maleic hydrazide with a wetting agent. Follow the manufacturer's directions.

CURING Here onions are being cured in crates in the field. They will not be topped until the bulbs are completely dry.

Grading

Grading is usually done over inclined screens or slatted racks which allow loose tops and dirt to pass through. A section of the grader is often equipped with forced draft from below and suction directly above. Such an arrangement removes most of the dry outer scales which have broken loose from the bulbs during harvesting and handling operations.

The United States grades are the only widely recognized standards; these may be modified from time to time by rulings issued by the U. S. Department of Agriculture. There are two sets of grades—one for early or Bermuda onions, and one for the late crop. Copies of the United States grade standards may be obtained from the Office of Shipping Point Inspection, State Department of Agriculture, Sacramento, California. In addition, the Bureau of Fruit and Vegetable Standardization of the State Department of Agriculture can supply copies of the state standards as defined in the Agricultural Code of California.

SPECIAL ASPECTS

Dry onion sets, green bunching onions, seed production are special aspects of onion growing.

Dry onion sets

Onion sets are small bulbs produced by growing the plants under crowded conditions in the field. For small home gardens, sets are more satisfactory than raising the plants from seed. Onion-set production is of relatively minor importance in California, the greater part of this crop being produced in other states, especially near Chicago. Some onion sets are grown, however, along the south-central coastal region of California.

For onion-set production on rich soil, 80 to 100 pounds of seed are sown to the acre; on poor soils, 60 to 80 pounds. The seed may be sown by hand-seed drills or by gang drills of the type used for planting seed of the main onion crop. Some growers use special seeders that distribute the seed in several rows about an inch apart; others place on the spout of the drill a funnel-shaped spreader or a wide shoe that distributes the seed over an area 3 or 4 inches wide. The distance between rows is usually 12 to 14 inches, although this may be varied to suit the individual grower. The seed must be sown thickly to prevent sets from becoming too large. If the plants are more than one-half inch in diameter, they may tend to form seedstalks, an occurrence to be avoided in producing bulbs for market. If the sets are to be used to grow green bunching onions, the smaller sizes are more desirable, although the larger sets may produce a somewhat earlier crop.

Onions of the flat varieties are the most satisfactory for set production; they make globe-shaped sets that keep well in storage. Cultural requirements other than method and rate of planting are in general the same for sets as for the production of large bulbs.

When mature, the sets are loosened by running a U-shaped knife under the row. They are then gathered and placed in shallow trays with lath bottoms. Topping is seldom necessary, since the small tops shrivel up and are generally broken loose by handling and grading. The trays are left scattered a few days to dry, then stacked in the field until stored.

Even at the thicker rates of planting, some of the bulbs are too large for sets and can usually be sold as "picklers" or "boilers."

Green bunching onions

Green bunching onions are of considerable importance in some California localities. This phase of the industry is limited to small plantings and is well suited to the general market.

Bunching onions may be produced from multiplier onions, dry sets, or seeds. The multiplier onion does not produce bulbs, but multiplies by giving rise to a number of side shoots at the base of the original plant. If sets or seed are planted, a white variety should be selected, since such plants make a more attractive package than a colored variety.

In marketing this class of onions, the young plants are pulled, the roots trimmed, and the outside peeled off, leaving the stem white and clean. They are then tied in small bunches, with tops trimmed slightly, and are packed in crates or baskets for transport to market.

Seed production

California is the principal onion seed-producing area in the United States. Quantities of seed are produced in Sacramento, Yolo, Contra Costa, Lake, San Benito, and Imperial counties; smaller acreages in Kern, Riverside, and Butte. Two methods of seed production are followed: seed-to-seed and mother bulb-to-seed. The second is the method most commonly used.

The principal **seed-to-seed** crop is grown in Imperial County. The seed is drilled directly into the field about September 10. By the time cool winter temperatures set in, the plants are large enough for a seedstalk to be formed. In the spring when temperatures begin to rise, the plants send up seedstalks instead of producing a bulb crop. A mature crop of seed is thus grown in one year.

Only stock seed previously grown from mother bulbs should be used to grow a seed-to-seed crop. Successive seed crops grown without this precaution tend to produce easy-bolting strains which may lead to rather disastrous results when the seed is used to produce a bulb crop.

Experiments in the Imperial Valley have shown that for the seed-to-seed crop the date and rate of planting affect seed yields very significantly. Seed should be planted at the rate of about 5 pounds per acre, and planting should be completed by September 20.

Most of the onion-seed crop is produced by the **mother bulb-to-seed method.** The crop is handled as a biennial, and it takes two years to produce a single crop of seed. The mother bulbs used for seed purposes are grown the first year and are produced on both peat and mineral soils in the same manner as bulbs grown for the market. Mother bulbs of the standard storage varieties are planted in November and December. Bulbs of the early and intermediate varieties, which keep less well in storage, may be planted as early as September. Seedstalks are formed the following spring.

Storage temperature, bulb size, spacing, and time of planting all influence the yield of seed per acre. Mother bulbs to be planted for seed production should be stored at 50° to 55° F. Plants from such bulbs bloom earlier, ripen their seed earlier, and produce higher yields than plants from bulbs stored at higher or lower temperatures.

The highest seed yields are obtained from the closer spacings, the peak yields occurring when bulbs are planted so that they actually touch each other in the row. At the closest spacing the size of the bulb is not so important, but as the space between bulbs is increased, the size of the bulb becomes more important, with the larger bulbs giving the highest seed yields. As the planting date is delayed throughout the winter, there is a

SEED PRODUCTION

Photo above shows an onion-seed field in full bloom. In photo below onion seed is being dried by the sun in the field. Note canvas on the ground.

corresponding delay in the time of seed maturity of the late-planted bulbs, and seed yield decreases.

After early planting, good root development is made during the winter, although the top growth may be small. The seedstalks appear in late February or March, and the seedheads mature in July and August.

Since onion seed does not ripen uniformly, each head must be harvested individually. At harvest, the stalk is cut by hand just below the seedhead. The heads are dropped into a sack suspended from the shoulders of the cutter. The sacks, when full, are emptied into larger sacks or into seedtight wagon boxes. They are then hauled to large canvas sheets on which the heads are spread, about 5 inches deep, to dry. The heads should be turned daily to aid the drying.

Seed is extracted with wooden rollers or by special threshing machinery. After most of the chaff has been removed by fanning or screening, the seed is washed to float off the remaining chaff and light seed. The final cleaning is by machinery capable of removing all foreign matter and light seeds.

According to growers, 300 pounds of seed to the acre is considered a fair yield. Yields as high as 1,500 pounds per acre have, however, been reported by some growers.

DISEASES . . .

A number of diseases may attack the onion plant, but only two—downy mildew and pink root—are of major importance in California.

Downy mildew, or blight

Onion downy mildew is caused by the fungus *Peronospora destructor*. The first symptoms are spots of fine, violet-tinted down upon the leaves or seedstalks. Within a day or two the affected areas on the leaves become pale green and finally yellowish. The downy growth spreads, and eventually the diseased portions of the plant collapse.

In the field the disease generally appears in small patches and spreads to surrounding areas. Moist weather greatly aids its development.

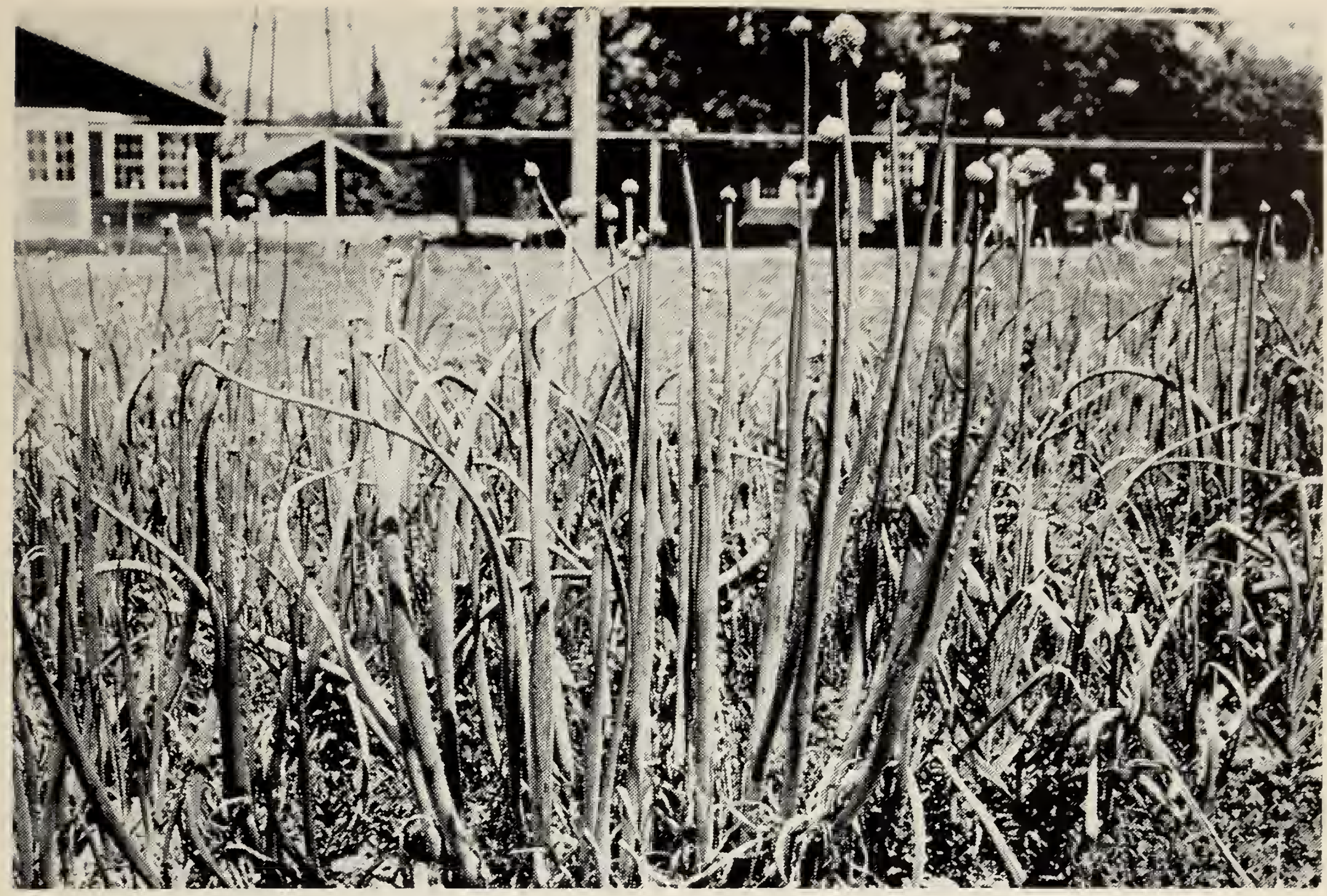
In California the chief damage is to the seed crop. High humidity (condensation of dew) and low-to-moderate temperatures favor the mildew, which attacks the seedstalks and causes them to curl or fall over before the seed is mature. Dusting with Dithane Z-78-Sulfur mixture at frequent intervals has been reported to give some control.

Several secondary invaders, such as *Botrytis, Alternaria, Stemphylium,* and *Cladosporium* spp., may attack the leaves and seedstalks in midseason or later. These weakly parasitic fungi always follow mildew, sometimes causing considerable damage. The bulbs may also be attacked. Control, if needed, is the same as for downy mildew.

Pink root

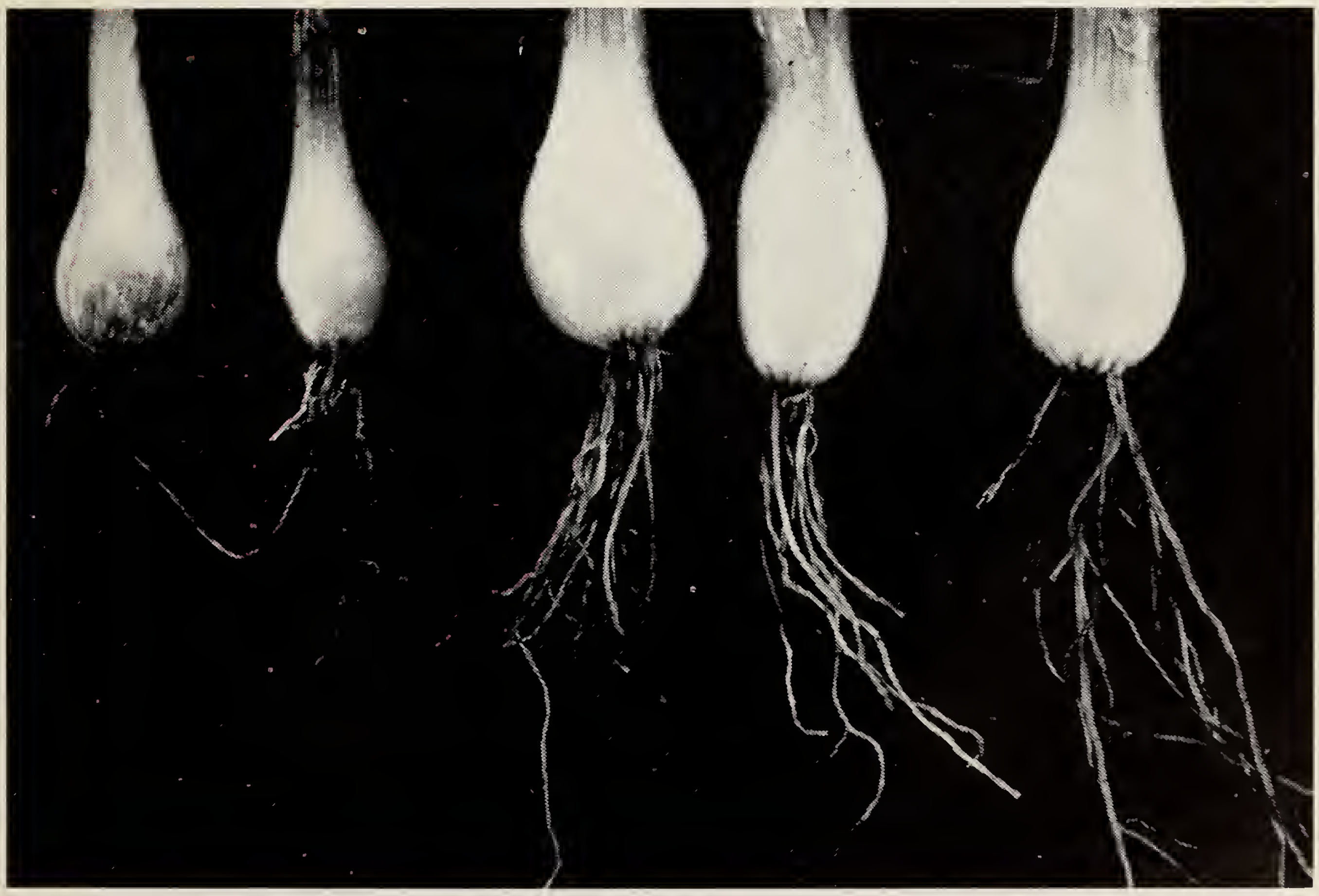
Pink root is caused by a fungus, *Phoma terrestris* (the same as *Pyrenochaeta terrestris*), that lives from year to year in the soil. The roots of affected plants turn pink, shrivel, and die. As the plant sends out new roots, they in turn eventually become infected and die. As a result, the plants are stunted, the bulbs small.

Heavily infested soil should not be used for onions or garlic. The wide range of plants susceptible to attack by the



DOWNY MILDEW . . . has caused the leaves of these plants to twist and curl. Darkened areas on stalks are caused by spore masses.

PINK ROOT . . . damage shows on these onions. The two on the left have been severely damaged. (Both photos courtesy Raymond G. Grogan.)



pink-root organism limits the effectiveness of crop rotation as a means of control. The development of onion varieties resistant to pink root seems to present the most helpful solution to the problem.

Neck rot, or botrytis rot

This gray, felt-like growth of mold caused by species of *Botrytis* appears at the neck or base of affected onions and softens and rots the tissue; it gradually destroys the whole bulb. In late stages the rotted tissue may be covered with a black, crust-like mass of fungus bodies called sclerotia. *Botrytis* may also attack the leaves and the seedstalks after mildew injury.

Suggested control measures include delaying the harvest until the plants are fully mature and properly curing the bulbs after harvest. White onions are more susceptible than colored.

Southern root rot

Southern root rot (*Sclerotium rolfsii*) generally attacks the outer scales, producing a dry rot of the bulb tissues. In storage the infected bulbs may be completely destroyed. This fungus may also grow up the hollow inside the seedstalk. Here, as well as on infected bulb tissue, the fruiting bodies, or sclerotia, may be formed. These bodies, about the size and color of mustard seed, act as the seeds of the mold and help to spread it. Once in the soil, this root rot persists for years.

Onions are moderately susceptible and cannot be planted on infested soil without danger of loss. White varieties are more susceptible than colored.

White rot

White rot is caused by *Sclerotium cepivorum.* Affected plants die from a rotting at the neck. At this point there is a surface crust of soil, together with a small, black fungus sclerotium and a thin web of white mold. Certain spots in the field covering several square yards may become infested.

Onions should not be planted where this disease has appeared; as soon as a spot is seen in the field, all the affected plants should be dug out and destroyed.

Black mold

Black mold, caused by the fungus *Aspergillus niger,* frequently develops in spots and streaks between the outer bulb scales, usually on onions in storage. Appearance and keeping quality may be seriously injured. Affected bulbs should not be placed in storage. Sound bulbs, if stored, should be thoroughly dried. Black mold should not be confused with smut.

Smut

Only a very small acreage in California is infested with the smut organism (*Urocystis cepulae*), which causes symptoms to appear soon after the seedlings emerge. Brown to black elongated blisters or pustules form within the scales or leaves, the pustules usually being

CAUTION

The enactment of recent legislation dealing with residues of agricultural pesticides allowable in raw agricultural products makes it necessary for growers to apply to onions only chemicals for which established tolerances have been set. For this reason, check with your local agricultural authorities to see that your insect-control program does not constitute a violation of the present law. For certain hazardous materials, at certain levels, it is necessary to post fields with "poison out" signs and obtain permits to conform to state and local laws.

somewhat thickened and often curved downward. Frequently the leaf splits, exposing a powdery black mass of spores inside the blister. Where this disease occurs, the soil becomes infested with smut spores, and the disease becomes worse in future crops planted on the same land.

This disease attacks only seedling plants. After they are about 3 inches high, they become immune. Onion sets or seedlings 3 to 4 inches high, grown on clean soil, may be transplanted to smut-infested soil and will not contract the disease.

Smut may be controlled by a formaldehyde solution applied in the furrow at planting time with a tank and drip attachment. The recommended concentration is 1 pint of commercial formalin (37 per cent formaldehyde) to 8 gallons of water at the rate of 200 gallons per acre, or 1 gallon to about 185 feet of row.

Smudge

Smudge is not known to occur in California, although it is a serious threat to onion crops elsewhere in the United States. The causal fungus is *Collectotrichum circinans*. The disease is confined largely to white varieties and appears in the field just before harvest; sometimes it continues to develop during storage. It is characterized by small dark-green to black dots on the outer scales. These dots are often arranged in concentric rings.

Ordinarily the disease causes very little damage to the bulbs, but it produces a dirty, unsightly appearance that reduces their market value. Prompt harvest and storage without undue exposure to moisture are the best methods of control.

Soft rot

Soft rot is caused by bacteria. The tissue first appears glassy or watersoaked and later disintegrates into a soft, watery mass, often with an offensive odor. Frequently the rot follows sunburn, freezing, and external bruises from careless handling, especially if surface wounds remain moist. It most frequently appears in storage. It can be controlled by careful handling to avoid injury and by rapid drying after harvest.

Yellow dwarf

This disease, caused by a virus, is so far of minor importance in California. It is transmitted from plant to plant by aphids and is spread from one crop to the next by overwintering plants. It is neither seed- nor soil-borne.

The symptoms are a yellow streaking followed by a general yellowing and crinkling of the leaves, which become more or less flat and droop over in the advanced stages of the disease. Flower stalks of infected seed plants are yellow, twisted, curly, and abnormally short. Such plants should be destroyed immediately.

. . . AND PESTS

Several insect, nematode, and mite pests attack onions. Under certain conditions they may seriously affect stands or yields.

Onion thrips

The onion thrips (*Thrips tabaci* Lind.) is perhaps the most widespread and damaging of those insects affecting onions. Typical damage is known as "blasting" or "silvering" of the leaves. Thrips may

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feed on onion flower parts and reduce seed yields; they can also feed on bulbs in storage.

These tiny insects puncture the plant cells and suck out the cell contents, causing the plant tissues to collapse and wither. White spots occur and run together to form larger silvery areas. The eggs are laid in the tender plant tissues, hatching into pale yellow larvae that hide in the angles of the leaves. The fringed-winged adults are pale yellow to grayish-brown and about 1/25 inch long. Usually five to six generations occur a year, and larvae and adults overwinter.

Chemical control is usually necessary, although Spanish onion types are more tolerant of attack, and overhead sprinkling may lessen damage. Chemicals in use include the following: a 10 per cent DDT dust plus 50 per cent sulfur at 30 pounds per acre, or DDT sprays containing 1 to 2 pounds actual chemical per acre; a 20 per cent toxaphene-sulfur dust at 30 pounds per acre, or a toxaphene spray containing 3 pounds actual chemical per acre; a 2 per cent parathion dust at 30 pounds per acre, or parathion spray containing 0.5 to 1 pound actual chemical per acre; and dieldrin or heptachlor sprays or dusts containing 0.5 to 1 pound actual chemical per acre.

Chemicals should be applied when the nymphs appear in the leaf angles. Applications may have to be repeated at frequent intervals depending upon the extent of the infestation. Control can usually be achieved by thorough coverage of the bases of the leaves where the nymphs hide.

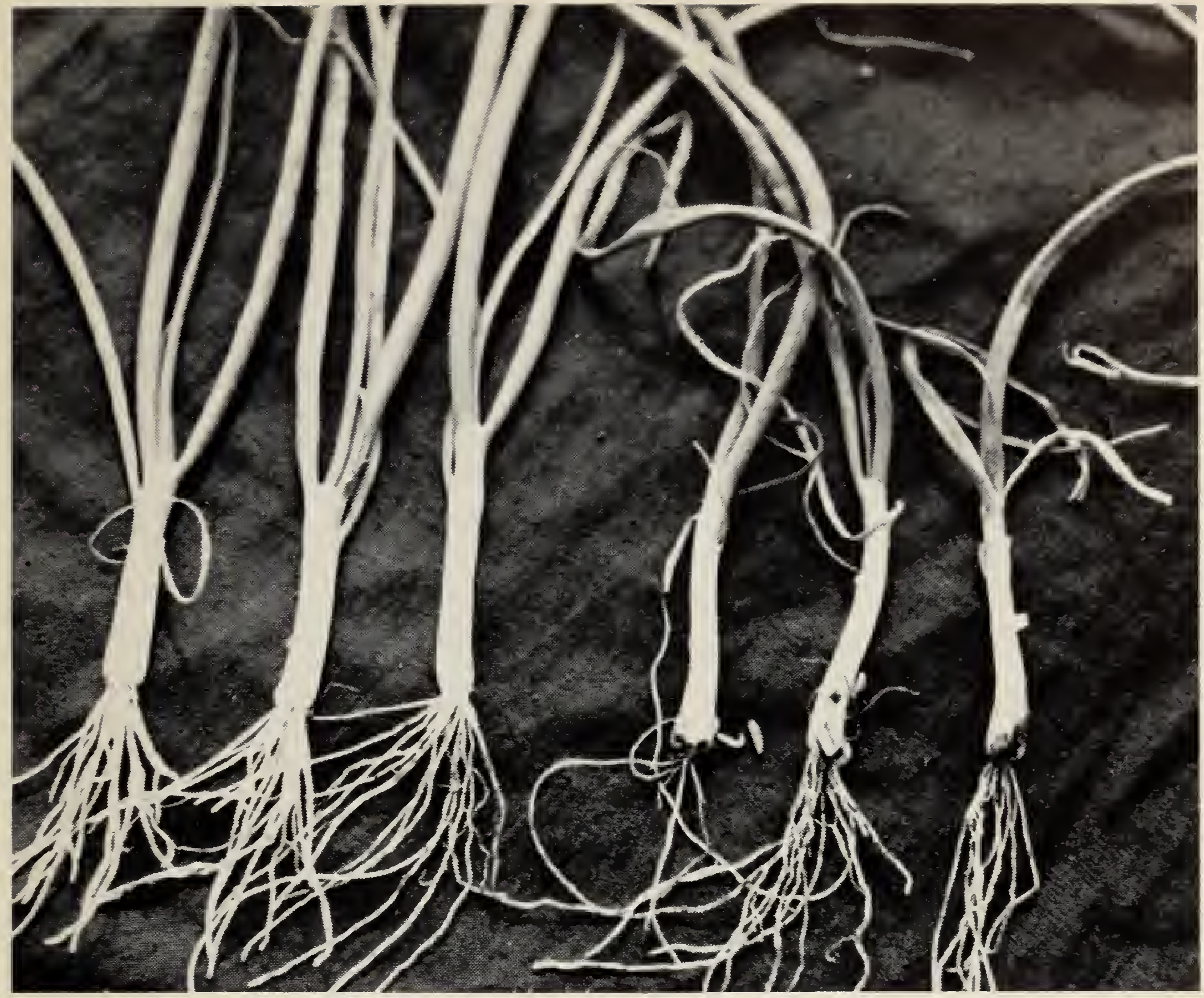
Maggots

Two species of maggots commonly attack onions; the onion maggot, *Hylemya antiqua* Meigen, which occurs chiefly in coastal areas, and the seed-corn maggot, *Hylemya cilicrura* (Rond.), which damages seedling onions in coastal and interior regions. The presence of white, legless maggots in the stems or bulbs is an indication of infestation. The onion maggot may attack onions of any age, but the seed-corn maggot confines its attack to germinating seeds and the succulent stems of seedlings. Damage may result in stunting, yellowing, or death. Damaged bulbs may rot in storage.

For onion maggot, soil and top treatments with aldrin, dieldrin, or heptachlor have proved satisfactory in most cases. Soil applications, using 2 to 5 pounds of actual chemical per acre, are effective in seedbeds, followed by several applications of top treatments as the onions emerge. In the field, 3 to 5 applications of 2–5 per cent dusts at 30 to 40 pounds per acre, or equivalent amounts of spray, are effective.

For seed-corn maggot, the seed should

Allowable tolerances on tops and bulbs at the time of harvest are: DDT, 7 ppm (parts per million); toxaphene, 7 ppm; parathion, 1 ppm; dieldrin, 0.1 ppm; and heptachlor 0.1 ppm.



MAGGOT DAMAGE shows on the plants on the right. Those on the left are healthy. Note the maggot near third plant from the right.

be treated with lindane, aldrin, dieldrin, or heptachlor at 1.33 ounces of 75 per cent, or the equivalent of 1 ounce of the actual chemicals per 100 pounds of seed —all used with an appropriate fungicide. Soil applications of aldrin, dieldrin, or heptachlor at 2 pounds of actual chemical per acre, followed by a 1–2-pound application as the plants emerge, may be necessary under severe maggot conditions.

Stem nematode

The stem and bulb nematode (*Ditylenchus dipsaci* Kuehn) is a minor pest of onions, but it could become important. These tiny worms cause the onions to have a bloated appearance, and as the season progresses the infected onions decay. Since it is a severe pest of garlic in certain areas, onions should not be planted in soil that is known to be infected.

Red spiders

Red spider mites may occasionally attack onions. The brown wheat mite, *Petrobia latens* (Muller), is a large, free-living mite that damages onions in certain areas. A 2 per cent parathion dust at 30–40 pounds per acre is an effective control. During warm weather, sulfur dust gives good control.

Occasional pests

The Japanese onion aphid, *Micromyzus formosanus* (Takahashi), occasionally damages field and stored onions. Leafmining flies, *Liriomyza* sp., often mine the leaves, making serpentine mines. Control is usually not necessary. Wireworms, *Limonius* spp., cause damage to onions in certain areas. Pre-treatment of the soil with aldrin, DDT, or heptachlor is effective; so is fumigation with ethylene dibromide. The bulb mite, *Aceria tulipae* (Keifer), damages onions in storage and in the field. Onion sets can probably be fumigated with methyl bromide as garlic is. Dusting in the field with sulfur is only partly effective.

UP-TO-DATE CONTROL MEASURES

At the time this manual went to press, the recommendations given here for the control of both diseases and insect pests were the most satisfactory that had been developed. These measures may continue to be the most effective for some time; however, chemical advances in this field are being made so rapidly that improved materials or methods might soon be available. To take advantage of the latest developments and give your crop the best possible protection, consult your local Farm Advisor before planning your program of disease and pest control.

THE PAYOFF Pallet-loaded onions in a warehouse ready for shipment. In this photo the onions had been in storage for some time, had started to sprout.

ACKNOWLEDGMENTS

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In order that the information in our publications may be more intelligible it is sometimes necessary to use trade names of products or equipment rather than complicated descriptive or chemical identifications. In so doing it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

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The research goes on

While this manual was being printed the search for new and better ways to produce onions continued. The photo above shows the author, a University of California Farm Advisor, and a successful grower discussing a test project for six different onion varieties. The project got under way about 10 minutes after the photo was taken—the results, whether good or bad, will be recorded, evaluated, perhaps discarded.

But over the years such tests, conducted by the Agricultural Experiment Station and Extension Service, in cooperation with growers, manufacturers, processors, and the like, are furnishing information that will help to produce more and better food and fiber crops for California farmers.

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